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AIR MINISTRY
METEOROLOGICAL RESEARCH COMMITTEE.

M.R.P.23.
7 May 1942.

Report of the Sub-Committee on Long-Range Forecasting.

The sub-committee consisting of Prof.D.Brunt (Chairman), Mr.E.Gold, Mr.E.G.Bilham, Inst.Commdr. Suthons met at Stonehouse on April 23-24, 1942. Dr.A.H.R.Goldie, Dr.C.E.P. Brooks and Mr.J.Wadsworth also attended.

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1. Long-range forecasting by Pressure Waves.

A report by M.O.2. on the accuracy and applicability of specimen forecasted charts for the winter of 1932-33 was read. It was considered that the charts based on symmetry points were better than those based on extrapolation, but that the network of stations used was too sparse. Mr.Gold thought that some specimen charts should be drawn based on 100 stations instead of only 20 to 30. He suggested that the Symmetry-day should be calculated for a few additional stations and the results compared with interpolations from the existing charts. Prof.Brunt suggested that the irregular variations could be eliminated to some extent by reflecting only the cosine terms, since the sine terms should vanish when the time origin is at the Symmetry-day. It was also agreed that a table of dates of Symmetry-days should be prepared for various places with values of the Symmetry Index S and of the corresponding correlation coefficient r. The form of the pressure curve near a symmetry point should be examined and curves of the standard deviation between observed and forecasted pressures at different intervals after the Symmetry-day should be prepared, some from published values and others from data worked out independently, with a view to ascertaining the interval after the symmetry-day for which symmetry persists and hence the length of time ahead for which forecasts should be possible by this method.

In a number of cases in which the type of pressure distribution changes, the forecasted charts followed the same sequence but with a lag of about 3 days. In view of the fact that the forecasts were based on charts at intervals of 3 days, this was regarded as a favourable beginning. It was considered that the work should be continued, using higher harmonics and aiming at forecasts for a shorter period (about 6-7 days was suggested).

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Mr.Wadsworth has not yet covered the whole trial interval of 120 days, but it was considered that this trial has now gone sufficiently far to show that results of value can be expected for the winter period. A similar but shorter investigation for a summer period should be carried out as quickly as possible.

It was recommended that the method should be tried out forthwith on producing 6-day forecasts from current data. The application to 6-day forecasting would necessitate the employment of higher harmonics than those previously employed, and the preparation of daily charts instead of charts at 3-day intervals.

Such a trial would require considerable additional staff (see Appendix II), but it is considered essential for the following reasons:-

(a) to ascertain whether the limited information available now as compared with 1932-3 is sufficient to work the method. Even if the method is sound, it is of no immediate practical use if it requires observations from a greater area than that available to us at present,

(b) to enable the soundness of the method under actual working conditions to be finally decided one way or the other in the shortest possible time,

(c) the charts, etc., constructed, and the experience gained during the trial would, if the trial is successful, enable the routine issue of forecasts to commence with the least possible delay.

No other procedure appears likely to make the results of this method of forecasting, if it is found to be reliable, available for operational purposes this year.

For security reasons, Mr.Gold considered that this work should be carried out at Dunstable.

2. Preliminary results of a periodogram analysis of 20 years pressure data at Stockholm, made by Dr.Brooks by approximate methods, were then discussed (see Appendix I). It was agreed that this should be completed and a comparison made with the results of more exact harmonic analysis, over a period of about a year. The work should then be extended to other stations. It was estimated that to carry out this investigation for about 17 stations within six months would require a staff of 4.

3. Singularities. M.R.P.11 and 11A were next discussed. Mr.Bilham said that he had consulted some senior forecasters and their opinion was that the memoranda on singularities were of use in amplifying and extending the information about the climatology of the region, and should help in framing the Further Outlook. Mr.Belasco's detailed studies of the synoptic situations preceding singularities in individual years would provide a useful index for reference by the forecasters if it were completed. It was felt that the reports on singularities should be circulated only to meteorologists because of the risk that non-meteorologists would use them as actual forecasts, unless accompanied by a warning that they were not forecasts but statistical summaries of what had occurred in past years.

It was agreed that further research into the causes of the occurrence and variation of singularities was required, and the general lines of the research proposed in M.R.P.11 were approved.

The increase of staff required to carry out this work is shown in Appendix II.

4. Classification of Synoptic Charts. It was decided that this work was of value as providing a background for the forecaster in preparing the Further Outlook, for linking other lines of investigation and for indexing conditions, and that it should be continued on lines planned. It was agreed that ice and ocean current conditions which change only slowly were the features most likely to be correlated with weather types and that the work proposed under this heading should be carried out. It was also considered that the question of applying present information about ice conditions to long-period forecasting of types should be investigated.

This investigation has so far been carried out by staff attached to A.D.M.O.(C. & I.). It was recommended that any ad hoc staff required should be provided. The Sub-Committee suggested that a table of pressure types for each day might be included in future in each volume of the Observatories Year Book.

5. The importance of a measure of activity over various areas of the weather maps having been discussed, it was agreed that M.O.2. should be asked to arrange for tabulation of a suitable index and for the information to be sent to Stonehouse. Dr.Brooks was to send a note to Dunstable on work done in the past in this connection.

6. General. It was considered that the work on pressure waves being a direct method was likely to give the most readily applicable results for 6-day forecasting on current data, but that the other inquiries must also be prosecuted simultaneously. Prof.Brunt compared a departure of the atmospheric circulation from normal with the switching of a railway train at a junction. At first the course taken by the train would be approximately parallel to its old course, but very soon a completely different direction might be followed. Here a small variation in the initial conditions produces a large variation in the final state of the system. It is not yet clear how large an initial variation from the mean conditions is a necessary preliminary to a large variation in the eventual meteorological situation. The problem of forecasting the weather over a long period requires careful consideration of the nature of the salient factors involved in the changes produced in weather conditions, and of the relation of the modifications in the initial conditions to the changes which they produce in the later development.

The Committee were unanimously agreed that the prospect of eventually attaining a high degree of success in long-range forecasting depended on tying up the work on pressure waves with other lines of research which might throw light on the physical processes involved in atmospheric changes. For this reason they recommend that all the lines of research which they discussed should be prosecuted with the greatest vigour.

Appendix I.

Analysis of Daily Pressures at Stockholm, 1919-1938.

With a view to determining the relative frequency and persistence of various pressure waves over a long period, 20 years of daily pressures at Stockholm are being analysed by my "difference-periodogram". The analysis has not yet been completed but has gone far enough to provide a rough periodicity "spectrum". The table below shows concentrations about 12-13, 16-17, 20, 24-25, 36, 50 and 67 days. The average duration of the shorter waves is of the order of four months and of the longer waves of six months. The figures may be modified slightly when the phases and amplitudes have been calculated.

The analysis of 20 years for a single station requires two computers for nearly three weeks, and about a week of the time of a skilled operator. It would seem desirable to carry out a similar analysis for a network of stations in Western Europe and the neighbouring Atlantic.

	Frequency	Average Duration
7-8	4	84
9-10	5	119
11	0	-
12-13	9	202
14-15	1	127
16-17	6	150
18	0	-
19-21	6	172
22-23	1	54
24-25	11	144
26	0	-
27-34	3	297
35-37	6	244
38-44	0	-
45-48	3	355
49-51	7	349
52-63	2	211
64	0	-
65-69	6	215
72	1	118

Appendix II.

Staff for Researches Proposed.

1. Medium-Range forecasting by Pressure Waves.

A precise estimate of staff is very difficult until some experience has been obtained under working conditions. With this limitation the following estimates have been made of the minimum staff required:

(a) On the assumption that both research and day-to-day forecasting are carried out at Stonehouse, a total staff of about 30 will be required for both purposes.

1. Current charting of harmonics. 1 Met.II, 9 Assistants.
   - 1.1 72 day interval for long waves
   - 1.2 24 or 12-day interval for short waves
   - 1.3 Non-cyclic change
   - 1.4 Synthesis of selected harmonics

2. Symmetry indexes. 1 Met.II, 4 Assistants.
   - 2.1 Extraction of data and preparation of pressure graphs at selected stations
   - 2.2 Calculation of Symmetry indexes and/or correlation coefficients
   - 2.3 Phase diagrams
   - 2.4 Use of symmetry slide rule
   - 2.5 Calculation of symmetry indexes from Fourier terms

3. Forecasting of Isobars and Air Masses. 1 Met II, 7 Assistants
   - 3.1 By symmetry points at individual stations
   - 3.2 By direct reflection of weather maps
   - 3.3 By extrapolation of harmonics
   - 3.4 Constructing of trajectories, upper air gradients etc.

4. Continuation of research at present rate. 1 Met.II, 3 Assistants.

5. Administration and control, 3.

The staff of 30 should be made up as follows:-

1 Officer in Charge
4 Met.II's.
2 Draughtswomen
23 Met. Assts. C.A.'s or T.C.'s of which at least 16 should be Met. Assts. The majority of the junior staff must be able to plot clearly.

(b) On the assumption that the research will be continued at Stonehouse but the current forecasting of pressure charts will be carried out at Dunstable in two shifts:- +

One additional Technical Officer will be required to supervise work at Dunstable.

Each shift will require 2 Met.II's, raising the number in this grade from 4 to 6. An additional draughtswoman would be required, to provide 2 for current work and 1 for research.

The difficulties of administration would be increased, and 1 extra C.A. would be required to meet this. Otherwise the staff required would be about the same except in so far as the current work would be slowed up by tracing charts for long periods by artificial light. The total staff under these conditions may be estimated as 35 made up of:-

	Stonehouse Research at present rate and administration.	Dunstable Current forecasting on 2-shift system.
Officer in Charge	1	0
Technical Officer	0	1
Met.II	1	5
Draughtswomen	1	2
Met. Assistants and Clerical Assistants	4	20

+ The proposal to work in two shifts at Dunstable is made mainly in order to economise in accommodation.

Appendix II. (Contd.)

B. Work on Singularities.

The further work on Singularities recommended by the Sub-Committee will involve an increase in the present junior staff by 5, of which 1 or 2 should be Met. Assts. and the remainder T.C.III's. The present junior staff is 1 Met. Asst., 1 W.A.A.F., 1 T.C.III.

The allocation will be as follows:-

Study of singularities and their inter-relations.

1 Technical Officer (part time) and 1 Met. Assistant.

Environmental conditions.

1 Met.II, 1 Met. Asst., 1 T.C.III.

Relations to pressure types and abnormal seasons.

1 Met.II, 1 Met.Asst., or T.C.III.

Analysis of Pressure waves 1919-38.

1 Clerical Officer (part time), 1 Met.Asst., 1 W.A.A.F., 2 T.C.III.'s.

One additional Met. Asst. is already provided for in the establishment (and is now urgently required). The 4 additional staff are accounted for by the work on pressure waves, which was not previously part of the programme.

A full-time T.O. is also required to take charge of all the statistical work in connection with the above, and the periodogram analysis referred to in para.2 of the minutes, and to set Dr.Brooks free to correlate the various lines of investigation.

C. Classification of Synoptic Charts.

1 additional Met.II.